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PATENT APPLICATION
Docket No. 13676.142

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Box PATENT APPLICATION
Assistant Commissioner for Patents
Washington, D.C. 20231

Sir:

Transmitted herewith for filing is the patent application of Richard L. Bonkowski, Patrick K. Higgins, Charles T. Markantes, and Roger W. Phillips for DIFFRACTIVE SURFACES WITH COLOR SHIFTING BACKGROUNDS comprising 32 pages of specification and claims.

Enclosed also are:

- ☒ Three (3) sheets of drawings.
- ☐ An assignment of the invention to _____, including a Form PTO-1595 recordation cover sheet.
- ☐ Priority to _____ Patent Application No. _____ filed _____ is claimed under 35 U.S.C. § 119.
- ☐ A Verified Statement to Establish Small Entity Status Under 37 C.F.R. § 1.9 and 37 C.F.R. § 1.27.
- ☒ A Certificate of Mailing by "Express Mail" certifying a filing date of July 8, 1999 by use of Express Mail Label No. EL360910673US.

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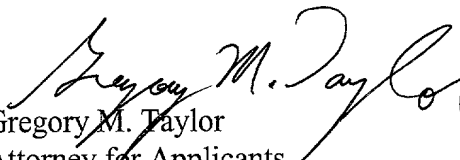
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— Any patent application processing fees under 37 C.F.R. § 1.17.

Please address all future correspondence in connection with the above-identified patent application to the attention of the undersigned.

Dated this 8th day of July 1999.

Respectfully submitted,


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PATENT APPLICATION
Docket No. 13676.142

UNITED STATES PATENT APPLICATION

of

RICHARD L. BONKOWSKI

PATRICK K. HIGGINS

CHARLES T. MARKANTES

and

ROGER W. PHILLIPS

for

**DIFFRACTIVE SURFACES WITH
COLOR SHIFTING BACKGROUNDS**

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BACKGROUND OF THE INVENTION

1. The Field of the Invention

The present invention is related generally to thin film optical coatings for use in producing security articles. More specifically, the present invention is related to the production of diffractive surfaces such as holograms or gratings having color shifting or optically variable backgrounds which can be used as security articles in a variety of applications.

2. The Relevant Technology

Color shifting pigments and colorants have been used in numerous applications, ranging from automobile paints to anti-counterfeiting inks for security documents and currency. Such pigments and colorants exhibit the property of changing color upon variation of the angle of incident light, or as the viewing angle of the observer is shifted. The primary method used to achieve such color shifting colorants is to disperse small flakes, which are typically composed of multiple layers of thin films having particular optical characteristics, throughout a medium such as paint or ink that may then be subsequently applied to the surface of an object.

Diffraction patterns and embossments, and the related field of holographs, have begun to find wide-ranging practical applications due to their aesthetic and utilitarian visual effects. One very desirable decorative effect is the iridescent visual effect created by a diffraction grating. This striking visual effect occurs when ambient light is diffracted into its color components by reflection from the diffraction grating. In general, diffraction gratings are essentially repetitive structures made of lines or grooves in a material to form a peak and trough structure. Desired optical effects within the visible spectrum occur when diffraction gratings have regularly spaced grooves in the range of hundreds to thousands of lines per millimeter on a reflective surface.

1 Diffraction grating technology has been employed in the formation of two-
2 dimensional holographic patterns which create the illusion of a three-dimensional image to
3 an observer. Furthermore, the use of holographic images on various objects to discourage
4 counterfeiting has found widespread application.

5 There currently exist several applications for surfaces embossed with holographic
6 patterns which range from decorative items, such as gift wrap, to security documents, such
7 as bank notes and credit cards. Two-dimensional holograms typically utilize diffraction
8 patterns which have been formed on a plastic surface. In some cases, a holographic image
9 which has been embossed on such a surface can be visible without further processing;
10 however, it is generally necessary, in order to achieve maximum optical effects, to place a
11 reflective layer, typically a thin metal layer such as aluminum, onto the embossed surface.
12 The reflective layer substantially increases the visibility of the diffraction pattern
13 embossment.

14 Unfortunately, there exists a substantial incentive for counterfeiters to reproduce the
15 holograms which are frequently used in credit cards, bank notes, and the like. One of the
16 methods used to reproduce holograms is to scan a laser beam across the embossed surface
17 and optically record the reflected beam on a layer of a material such as a photopolymerizable
18 polymer. The original pattern can subsequently be reproduced as a counterfeit. Another
19 method is to remove the protective covering material from the embossed metal surface by
20 ion etching, and then when the embossed metal surface is exposed, a layer of metal such as
21 silver (or any other easily releasable layer) can be deposited. This is followed by deposition
22 of a layer of nickel, which is subsequently released to form a counterfeiting embossing shim.

23 Due to the level of sophistication of counterfeiting methods, it has become necessary
24 to develop more advanced security measures. One approach, as disclosed in U.S. Patent Nos.
25 5,629,068 and 5,549,774 to Miekka et al., is the application of inks, such as metallic flake
26 inks, metallic effect inks, or inks with pigments formed of optical stacks, upon the embossed

1 surface in lieu of a thin metal layer. In another approach, disclosed in U.S. Patent Nos.
2 5,624,076 and 5,672,410 also to Miekka et al., embossed metal particles or optical stack
3 flakes are used to produce a holographic image pattern.

4 Another problem with the holographic images as described above is that they require
5 direct specular illumination in order to be visualized. This means that for best viewing
6 results, the illuminating light must be incident at the same angle as the viewing angle.
7 Therefore, diffuse light sources, such as ordinary room lights or viewing by an overcast sky,
8 when used to illuminate the holographic image, do not reveal much of the visual information
9 contained in the hologram, and what is typically seen is only a silver colored reflection from
10 the embossed surface.

11 It would therefore be of substantial advantage to develop improved security products
12 to provide enhanced viewing qualities in ordinary room light and which are usable in various
13 security applications to make counterfeiting more difficult.

SUMMARY AND OBJECTS OF THE INVENTION

It is a primary object of the invention to provide a security article have color shifting properties which increases the difficulty of counterfeiting in a variety of applications.

Another object of the invention to provide a security article with a distinctive pattern that is readily observable over a wide range of viewing angles in diffuse lighting conditions.

Another object of the invention is to provide a security article with a holographic pattern that has enhanced visibility and contrast to provide for viewing under diffuse lighting conditions without the need for direct specular light.

Another object of the invention to provide a security article that can be manufactured at low cost compared to prior security products.

To achieve the forgoing objects and in accordance with the invention as embodied and broadly described herein, a security article is provided which includes a light transmissive substrate having a first surface and an opposing second surface, with the first surface having an optical interference pattern such as a diffraction grating pattern or a holographic image pattern. A color shifting optical coating is formed on the substrate, with the optical coating providing an observable color shift as the angle of incident light or viewing angle changes. In one embodiment, the color shifting optical coating is formed on the second surface of the substrate opposite from the optical interference pattern, and includes an absorber layer formed adjacent to the substrate, a dielectric layer formed on the absorber layer, and a reflector layer formed on the dielectric layer. Alternatively, this multilayer optical coating can be formed on the same side of the substrate as the interference pattern.

In another embodiment, the color shifting optical coating is applied to the substrate in the form of a paint or ink which includes a polymeric medium and a plurality of color shifting multilayer optical interference flakes dispersed in the polymeric medium. In other embodiments, the color shifting optical coating is coextruded with a light transmissive

1 embossed substrate to form adjacent layers or is dispersed in the form of interference flakes
2 in the substrate material prior to forming the substrate.

3 The security article of the invention can be used in a variety of applications to provide
4 for enhanced security measures such as anticounterfeiting. The security article can be
5 utilized in the form of a label, a tag, a ribbon, a security thread, and the like, for application
6 in a variety of objects such as security documents, monetary currency, credit cards,
7 merchandise, etc.

8 These and other aspects and features of the present invention will become more fully
9 apparent from the following description and appended claims, or may be learned by the
10 practice of the invention as set forth hereinafter.

1 **BRIEF DESCRIPTION OF THE DRAWINGS**

2 In order to more fully understand the manner in which the above-recited and other
3 advantages and objects of the invention are obtained, a more particular description of the
4 invention will be rendered by reference to specific embodiments thereof which are illustrated
5 in the appended drawings. Understanding that these drawings depict only typical
6 embodiments of the invention and are not therefore to be considered as limiting of its scope,
7 the invention will be described and explained with additional specificity and detail through
8 the use of accompanying drawings in which:

9 Figure 1A is a schematic depiction of a security article having a color shifting optical
10 coating according to one embodiment of the present invention;

11 Figure 1B is a schematic depiction of a security article having a color shifting optical
12 coating according to an alternative embodiment of the present invention;

13 Figure 2A is a schematic depiction of a security article having a color shifting optical
14 coating according to another embodiment of the present invention;

15 Figure 2B is a schematic depiction of a security article having a color shifting optical
16 coating according to an alternative embodiment of the present invention;

17 Figure 3 is a schematic depiction of a security article according to yet another
18 embodiment of the present invention;

19 Figure 4 is a schematic depiction of a security article according to a further
20 embodiment of the present invention;

21 Figure 5 is a schematic depiction of the security article of Figure 1A with a release
22 layer formed thereon;

23 Figure 6 is a schematic depiction of the security article of Figure 1A attached to a
24 carrier substrate;

25 Figure 7 is a schematic depiction of the security article of Figure 1B with a release
26 layer formed thereon; and

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Figure 8 is a schematic depiction of the security article of Figure 1B attached to a carrier substrate.

DETAILED DESCRIPTION OF THE INVENTION

The present invention is directed to security articles having diffractive surfaces with color shifting backgrounds that produce enhanced visual effects. The configuration of the security articles is such that a combination of either holographic or diffraction grating patterns with color shifting films or layers decreases the possibility of counterfeiting. Furthermore, the article of the invention allows a user to more easily view the image or diffraction effect in diffuse light without the need for direct specular light.

Generally, the configuration of the security articles of the present invention is such that the combination of a light transmissive substrate, having an interference pattern on the surface thereof, with color shifting optical coatings provides security features that make forgery or counterfeiting of an object difficult.

Referring to the drawings, wherein like structures are provided with like reference designations, Figure 1A depicts a security article 10 according to one embodiment of the present invention. The security article 10 includes a light transmissive substrate 14 formed with an optical interference pattern 15 on an outer first surface thereof. A color shifting optical coating 16 is formed on an opposing second surface of substrate 14 and is discussed in further detail below. The combination of substrate 14 and color shifting optical coating 16 forming security article 10 provide a security feature that reduces the possibility of duplication, forgery and/or counterfeiting of an object having security article 10 thereon.

The optical interference pattern 15 formed on the outer surface of light transmissive substrate 14 can take various conventional forms including diffraction patterns such as diffraction gratings, refraction patterns, holographic patterns such as two-dimensional and three-dimensional holographic images, corner cube reflectors, or other like interference patterns. The particular methods and structures that form optical interference pattern 15 are known by those skilled in the art. For example, embossing the light transmissive substrate to form an interference pattern thereon can be done by well known methods, such as

1 embossing the surface of a plastic film by pressing it in contact with a heated nickel
2 embossing shim at high pressure. Other methods include photolithography, molding of the
3 plastic film against a patterned surface, and the like.

4 Generally, moldable materials are used to form light transmissive substrate 14 and
5 include, for example, plastics such as polyethylene terephthalate (PET), especially PET type
6 G, polycarbonate, acrylics such as polyacrylates including polymethyl methacrylate
7 (PMMA), polyacrylonitrile, polyvinyl chloride, polystyrene, polypropylene, polynaphthalene
8 terephthalate (PNT), mixtures or copolymers thereof, and the like. It is preferred that light
9 transmissive substrate 14 be substantially composed of a transparent material such as
10 polycarbonate. The substrate 14 is formed to have a suitable thickness of about 5 μ m to about
11 100 μ m, and preferably a thickness of about 12 μ m to about 25 μ m. In addition, substrate 14
12 can be made of one layer or multiple layers of substrate materials.

13 In one embodiment, substrate 14 can be produced from a thermoplastic film that has
14 been embossed by heat softening the surface of the film and then passing the film through
15 embossing rollers which impart the diffraction grating or holographic image onto the
16 softened surface. In this way, sheets of effectively unlimited length can be formed with the
17 diffraction grating or holographic image thereon.

18 As shown in Figure 1A, the color shifting optical coating 16 is a multilayer optical
19 interference film that includes an absorber layer 18, a dielectric layer 20, and a reflector layer
20 22. The absorber layer 18 is deposited on light transmissive substrate 14 by a conventional
21 deposition process such as physical vapor deposition (PVD), sputtering, or the like. The
22 absorber layer 18 is formed to have a suitable thickness of about 30-150 Angstroms (\AA), and
23 preferably a thickness of about 50-100 \AA . The absorber layer 18 can be composed of a semi-
24 opaque material such as a grey metal, including metals such as chromium, nickel, titanium,
25 vanadium, cobalt, and palladium, as well as other metals such as iron, tungsten,
26 molybdenum, niobium, aluminum, and the like. Various combinations and alloys of the

1 above metals may also be utilized, such as Inconel (Ni-Cr-Fe). Other absorber materials may
2 also be employed in absorber layer 18 including metal compounds such as metal fluorides,
3 metal oxides, metal sulfides, metal nitrides, metal carbides, metal phosphides, metal
4 selenides, metal silicides, and combinations thereof, as well as carbon, germanium, cermet,
5 ferric oxide, metals mixed in a dielectric matrix, and the like.

6 The dielectric layer 20 is formed on absorber layer 18 by a conventional deposition
7 process such as PVD, reactive DC sputtering, RF sputtering, or the like. The dielectric layer
8 20 is formed to have an effective optical thickness for imparting color shifting properties to
9 security article 10. The optical thickness is a well known optical parameter defined as the
10 product ηd , where η is the refractive index of the layer and d is the physical thickness of the
11 layer. Typically, the optical thickness of a layer is expressed in terms of a quarter wave
12 optical thickness (QWOT) that is equal to $4\eta d/\lambda$, where λ is the wavelength at which a
13 QWOT condition occurs. The optical thickness of dielectric layer 20 can range from about
14 2 QWOT at a design wavelength of about 400 nm to about 9 QWOT at a design wavelength
15 of about 700 nm, and preferably 2-6 QWOT at 400-700 nm, depending upon the color shift
16 desired. Suitable materials for dielectric layer 20 include those having a "high" index of
17 refraction, defined herein as greater than about 1.65, as well as those have a "low" index of
18 refraction, which is defined herein as about 1.65 or less.

19 Examples of suitable high refractive index materials for dielectric layer 20 include
20 zinc sulfide (ZnS), zinc oxide (ZnO), zirconium oxide (ZrO₂), titanium dioxide (TiO₂),
21 carbon (C), indium oxide (In₂O₃), indium-tin-oxide (ITO), tantalum pentoxide (Ta₂O₅), ceric
22 oxide (CeO₂), yttrium oxide (Y₂O₃), europium oxide (Eu₂O₃), iron oxides such as
23 (II)diiron(III) oxide (Fe₃O₄) and ferric oxide (Fe₂O₃), hafnium nitride (HfN), hafnium carbide
24 (HfC), hafnium oxide (HfO₂), lanthanum oxide (La₂O₃), magnesium oxide (MgO),
25 neodymium oxide (Nd₂O₃), praseodymium oxide (Pr₆O₁₁), samarium oxide (Sm₂O₃),
26 antimony trioxide (Sb₂O₃), silicon carbide (SiC), silicon nitride (Si₃N₄), silicon monoxide

1 (SiO), selenium trioxide (Se₂O₃), tin oxide (SnO₂), tungsten trioxide (WO₃), combinations
2 thereof, and the like.

3 Suitable low refractive index materials for dielectric layer 20 include silicon dioxide
4 (SiO₂), aluminum oxide (Al₂O₃), metal fluorides such as magnesium fluoride (MgF₂),
5 aluminum fluoride (AlF₃), cerium fluoride (CeF₃), lanthanum fluoride (LaF₃), sodium
6 aluminum fluorides (*e.g.*, Na₃AlF₆ or Na₅Al₃F₁₄), neodymium fluoride (NdF₃), samarium
7 fluoride (SmF₃), barium fluoride (BaF₂), calcium fluoride (CaF₂), lithium fluoride (LiF),
8 combinations thereof, or any other low index material having an index of refraction of about
9 1.65 or less. For example, organic monomers and polymers can be utilized as low index
10 materials, including dienes or alkenes such as acrylates (*e.g.*, methacrylate), perfluoroalkenes,
11 polytetrafluoroethylene (Teflon), fluorinated ethylene propylene (FEP), combinations
12 thereof, and the like.

13 The reflector layer 22 is formed on dielectric layer 20 by a conventional deposition
14 process such as PVD, sputtering, or the like. The reflector layer 22 is formed to have a
15 suitable thickness of about 300-1000 Å, and preferably a thickness of about 500-1000 Å. The
16 reflector layer 22 is preferably composed of an opaque, highly reflective metal such as
17 aluminum, silver, copper, gold, platinum, niobium, tin, combinations and alloys thereof, and
18 the like, depending on the color effects desired. It should be appreciated that semi-opaque
19 metals such as grey metals become opaque at approximately 350-400 Å. Thus, metals such
20 as chromium, nickel, titanium, vanadium, cobalt, and palladium, or cobalt-nickel alloys
21 (which would be magnetic), could also be used at an appropriate thickness for reflector layer
22 22.

23 In addition, reflector layer 22 can be composed of a magnetic material such as a
24 cobalt-nickel alloy, or can be formed of a semitransparent material, to provide for machine
25 readability for security verification. For example, machine readable information may be
26 placed on a backing underlying the optical coating, such as personal identification numbers

1 (PINS), account information, business identification of source, warranty information, or the
2 like. In an alternative embodiment, reflector layer 22 can be segmented to allow for partial
3 viewing of underlying information either visually or through the use of various optical,
4 electronic, magnetic, or other detector devices. This allows for detection of information
5 below optical coating 16, except in those locations where reflector segments are located,
6 thereby enhancing the difficulty in producing counterfeits. Additionally, since the reflector
7 layer is segmented in a controlled manner, the specific information prevented from being
8 read is controlled, providing enhanced protection from forgery or alteration.

9 By using an absorber/dielectric/reflector design for color shifting optical coating 16,
10 such as shown in Figure 1A, high chroma variable color effects are achieved that are
11 noticeable to the human eye. Thus, an object having security article 10 applied thereto will
12 change color depending upon variations in the viewing angle or the angle of the object
13 relative to the viewing eye. As a result, the variation in colors with viewing angle increases
14 the difficulty to forge or counterfeit security article 10. By way of example, the color-shifts
15 that can be achieved utilizing color shifting optical coating 16 in accordance with the present
16 invention include, but are not limited to, gold-to-green, green-to-magenta, blue-to-red, green-
17 to-silver, magenta-to-silver, magenta-to-gold, etc.

18 The color shifting properties of optical coating 16 can be controlled through proper
19 design of the layers thereof. Desired effects can be achieved through the variation of
20 parameters such as thickness of the layers and the index of refraction of each layer. The
21 changes in perceived color which occur for different viewing angles or angles of incident
22 light are a result of a combination of selective absorption of the materials comprising the
23 layers and wavelength dependent interference effects. The interference effects, which arise
24 from the superposition of the light waves that have undergone multiple reflections and
25 transmissions within the multilayered structure, are responsible for the shifts in perceived
26 color with different angles.

1 Figure 1B depicts a security article 30 according to an alternative embodiment of the
2 present invention. The security article 30 includes elements similar to those discussed above
3 with respect to security article 10, including a light transmissive substrate 14 formed with
4 an optical interference pattern on a surface thereof, and a color shifting optical coating 16
5 that is a multilayer film. The optical coating 16 is formed, however, on the same side as the
6 interference pattern on substrate 14 by conventional deposition processes. The optical
7 coating 16 includes an absorber layer 18 on the interference pattern, a dielectric layer 20 on
8 absorber layer 18, and a reflector layer 22 on dielectric layer 20. As shown in Figure 1B,
9 each of these layers formed on substrate 14 conforms to the shape of the interference pattern
10 such as a holographic image.

11 Figure 2A depicts a security article 40 according to another embodiment of the
12 present invention. The security article 40 includes elements similar to those discussed above
13 with respect to security article 10, including a light transmissive substrate 14 formed with
14 an optical interference pattern 15 on an outer first surface thereof, and a color shifting optical
15 coating 16 formed on an opposing second surface of substrate 14. The optical coating 16 is
16 a multilayer film that includes an absorber layer 18 and a dielectric layer 20 thereon, but does
17 not include the reflector layer. This allows optical coating 16 to be transparent to light
18 incident upon the surface thereof, thereby providing for visual verification or machine
19 readability of information below optical coating 16 on a carrier substrate (not shown).

20 Figure 2B depicts a security article 50 according to an alternative embodiment of the
21 present invention. The security article 50 includes elements similar to those discussed above
22 with respect to security article 40, including a light transmissive substrate 14 formed with
23 an optical interference pattern on a surface thereof, and a color shifting optical coating 16
24 that is a multilayer film. The optical coating 16 is formed, however, on the same side as the
25 interference pattern on substrate 14 by conventional deposition processes. The optical
26 coating 16 includes an absorber layer 18 on the interference pattern, and a dielectric layer 20

1 on absorber layer 18. This allows optical coating 16 to be transparent to light incident upon
2 the surface thereof, providing for visual verification or machine readability of information
3 on a carrier substrate.

4 Figure 3 depicts a security article 60 according to a further embodiment of the present
5 invention. The security article 60 includes elements similar to those discussed above with
6 respect to security article 10, including a light transmissive substrate 14 formed with an
7 optical interference pattern 15 on an outer first surface thereof, and a color shifting optical
8 coating 26 applied to an opposing second surface of substrate 14. The color shifting optical
9 coating 26 is formed from a layer of color shifting ink or paint that includes a polymeric
10 medium interspersed with a plurality of optical interference flakes having color shifting
11 properties.

12 The color shifting flakes of optical coating 26 are formed from a multilayer thin film
13 structure that includes the same basic layers as described above for the optical coating 16 of
14 security article 10. These include an absorber layer, a dielectric layer, and optionally a
15 reflector layer, all of which can be composed of the same materials discussed above in
16 relation to the layers of optical coating 16. The flakes can be formed to have a symmetrical
17 multilayer thin film structure, such as absorber/dielectric/reflector/dielectric/absorber, or
18 absorber/dielectric/absorber. Alternatively, the flakes can have a nonsymmetrical structure,
19 such as absorber/dielectric/reflector. The flakes are formed so that a dimension on any
20 surface thereof ranges from about 2 to about 200 microns.

21 Typically, the multilayer thin film structure is formed on a flexible web material with
22 a release layer thereon. The various layers are deposited on the web by methods well known
23 in the art of forming thin coating structures, such as PVD, sputtering, or the like. The
24 multilayer thin film structure is then removed from the web material as thin film flakes,
25 which can be added to a polymeric medium such as various pigment vehicles for use as an
26 ink or paint. In addition to the flakes, additives can be added to the inks or paints to obtain

1 desired color shifting results. These additives include lamellar pigments such as aluminum
2 flakes, graphite, mica flakes, and the like, as well as non-lamellar pigments such as
3 aluminum powder, carbon black, and other colorants such as organic and inorganic pigments,
4 and colored dyes.

5 Suitable embodiments of the flake structure are disclosed in a copending application
6 Serial Number 09/198,733, filed on November 24, 1998, and entitled "Color Shifting Thin
7 Film Pigments," which is incorporated herein by reference. Other suitable embodiments of
8 color shifting or optically variable flakes which can be used in paints or inks for application
9 in the present invention are described in U.S. Patent Nos. 5,135,812, 5,171,363, 5,278,590,
10 5,084,351, 4,838,648, and 4,168,983, the disclosures of which are incorporated herein by
11 reference.

12 For example, U.S. Patent No. 5,135,812 discloses a symmetrical optical multilayer
13 film which is composed either of transparent all-dielectric stacks, or transparent dielectric
14 and semi-transparent metallic layered stacks. In the case of an all-dielectric stack, the optical
15 coating is made of alternating layers of high and low index of refraction materials. In U.S.
16 Patent No. 5,278,590 to Phillips et al., a symmetrical three-layer optical interference coating
17 which can be formed into flakes is disclosed and includes first and second partially
18 transmitting absorber layers that have essentially the same composition and thickness, with
19 a dielectric spacer layer located between the first and second absorber layers. The dielectric
20 layer is composed of a material having a low index of refraction such as magnesium fluoride.

21 The color shifting ink or paint utilized to form optical coating 26 on security device
22 60 can be applied by conventional coating devices and methods known to those skilled in the
23 art. These include, for example, various printing methods such as silk screen, intaglio,
24 gravure or flexographic methods, and the like. Alternatively, optical coating 26 can be
25 formed on security device 60 by coextruding a polymeric material containing color shifting
26 flakes, with the plastic material used to form substrate 14 having interference pattern 15.

1 Figure 4 depicts a security article 70 according to another embodiment of the present
2 invention. The security article 70 includes a light transmissive substrate 14 formed with an
3 optical interference pattern 15 on an outer surface thereof. A color shifting pigment is
4 dispersed within substrate 14 and comprises a plurality of multilayer optical interference
5 flakes, such as those described above with respect to security article 40. The flakes are
6 dispersed within the material that forms substrate 14 prior to formation thereof. Preferably,
7 the flakes are oriented so that they lie parallel to the planar back surface of substrate 14
8 opposite from the outer surface thereof in order to provide maximum color shifting effects.

9 The various security articles as described above can be used in a variety of
10 applications to provide for enhanced security measures such as anticounterfeiting. The
11 security articles can be utilized in the form of a label, tag, ribbon, security thread, tape, and
12 the like, for application in a variety of objects such as security documents, monetary
13 currency, credit cards, merchandise packaging, license cards, negotiable notes, bank bonds,
14 paper, plastic, or glass products, or other similar objects.

15 The security articles of the invention can be transferred and attached to various
16 objects by a variety of conventional processes. For example, the security articles can applied
17 to an object by use of a release layer. Figure 5 shows security article 10 with a release layer
18 62 formed on substrate 14. The release layer 62 is of a suitable type to allow security article
19 10 to be removed therefrom during the application process, such as by a hot-stamping
20 process. The release layer 62 may be a polymeric material such as polyvinyl chloride,
21 polystyrene, chlorinated rubber, acrylonitrile-butadiene-styrene copolymer, nitrocellulose,
22 methyl methacrylate, acrylic copolymers, fatty acids, waxes, gums, gels, and mixtures
23 thereof. The release layer is coupled to a carrier structure 64, which can be part of various
24 manufacturing belts or other processing structures that assist in transferring security article
25 10 to the final structural element.
26

Figures 7-8 depict the method and final structure of affixing a security article, such as security article 30, to a carrier substrate 66 through a hot-stamping process. Figure 7 shows security article 30 with a release layer 62 formed on one side of a light transmissive substrate 24, such as an acrylic coating with an interference pattern formed thereon. The substrate 24 may be composed of other materials such as those discussed above relative to substrate 14, including polystyrene, polyacrylonitrile, polyvinyl chloride, and the like. The release layer 62 is formed on the side opposite from optical coating 16 on the interference pattern, and is attached to a carrier structure 64. The release layer 62 allows security article 30, including substrate 24, absorber layer 18, dielectric layer 20, and reflector layer 22, to be released from carrier structure 64 during the hot-stamping process.

Generally, carrier structure 64 can be composed of various materials with various thicknesses which are known by those skilled in the art. For example, when carrier structure 64 is formed of PET, the thickness preferably ranges from about 10 μm to about 75 μm . Other materials and thickness ranges are applicable in light of the teachings contained herein.

Furthermore, the thickness of light transmissive substrate 24, when taking the form of an acrylic material, can range from about 3 μm to about 20 μm with an embossed surface.

1 Generally, substrate 24 should have a lower melting point or glass transition temperature
2 than the optical coating, while being transparent.

3 Prior to hot-stamping, an adhesive layer 68 is formed on reflector layer 22, with the
4 adhesive layer having a thickness of about 2 μm to about 20 μm . As shown in Figure 8, the
5 release layer and carrier structure are removed when security article 30 has been applied to
6 an object such as a carrier substrate 66 by hot-stamping, with security article 30 being
7 coupled to carrier substrate 66 by way of adhesive layer 68. The bonding of adhesive layer
8 68 against carrier substrate 66 occurs as a heated metal stamp (not shown) comes into contact
9 with carrier structure 64. The heated metal stamp simultaneously forces adhesive layer 68
10 against carrier substrate 66 while heating adhesive layer 68 to more effectively bond to
11 carrier substrate 66. Furthermore, the heated metal stamp softens release layer 62 thereby
12 aiding in releasing security article 30 from carrier structure 64 which is subsequently
13 discarded. Once security article 30 has been attached to carrier substrate 66, the image
14 produced by security article 30 is viewed from substrate 24 toward optical coating 16.

15 The following examples are given to illustrate the present invention, and are not
16 intended to limit the scope of the invention.

17 18 Example 1

19 Optical coatings composed of color shifting flakes in a polymeric vehicle were
20 formed by a drawdown process on light transmissive substrates composed of PET films
21 containing a holographic image. The drawdown vehicle included two parts lacquer/catalyst
22 and one part color shifting flakes. The color shifting flakes utilized had color shifting
23 properties of green-to-magenta, blue-to-red, and magenta-to-gold.
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- 1 1. A security article comprising:
 - 2 a light transmissive substrate having a first surface and an opposing second
 - 3 surface, the first surface having an optical interference pattern; and
 - 4 a color shifting optical coating on the second surface of the substrate, the
 - 5 optical coating providing an observable color shift as the angle of incident light or
 - 6 viewing angle changes.
- 7
- 8 2. The security article of claim 1, wherein the substrate is composed of a plastic
- 9 material.
- 10
- 11 3. The security article of claim 2, wherein the plastic material is selected from
- 12 the group consisting of polyethylene terephthalate, polycarbonate, polyvinyl chloride,
- 13 polyacrylates, polyacrylonitrile, polystyrene, polypropylene, polynaphthalene terephthalate,
- 14 and mixtures or copolymers thereof.
- 15
- 16 4. The security article of claim 1, wherein the optical interference pattern is a
- 17 diffraction grating pattern or a holographic image pattern.
- 18
- 19 5. The security article of claim 1, wherein the color shifting optical coating is
- 20 a multilayer optical interference film including an absorber layer on the second surface of the
- 21 substrate, and a dielectric layer on the absorber layer.
- 22
- 23 6. The security article of claim 1, wherein the color shifting optical coating is
- 24 a multilayer optical interference film including an absorber layer on the second surface of the
- 25 substrate, a dielectric layer on the absorber layer, and a reflector layer on the dielectric layer.
- 26

Variable	Mean	SD	Min	Max
Age	35.2	12.5	18	65
Gender	0.52	0.50	0	1
Marital status	0.68	0.48	0	1
Education	12.5	2.1	9	16
Income	15.2	8.5	5	35
Occupation	1.2	0.8	0	2
Health status	1.8	0.9	1	3
Stress level	2.5	1.2	1	4
Life satisfaction	3.2	1.5	1	5
Resilience	2.8	1.1	1	4
Optimism	3.5	1.3	1	5
Gratitude	3.8	1.4	1	5
Forgiveness	3.6	1.3	1	5
Empathy	3.4	1.2	1	5
Compassion	3.3	1.1	1	5
Kindness	3.1	1.0	1	5
Generosity	3.0	0.9	1	5
Patience	2.9	0.8	1	5
Self-control	2.7	0.7	1	5
Emotional stability	2.6	0.6	1	5
Psychological well-being	2.5	0.5	1	5
Life purpose	2.4	0.4	1	5
Meaning in life	2.3	0.3	1	5
Existential well-being	2.2	0.2	1	5
Transcendental well-being	2.1	0.1	1	5
Overall well-being	2.0	0.0	1	5

A PROFESSIONAL CORPORATION

ATTORNEYS AT LAW

1000 EAGLE GATE TOWER

60 EAST SOUTH TEMPLE

SALT LAKE CITY, UTAH 84111

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8. The security article of claim 1, further comprising a release layer on the substrate.

1 9. A security article comprising:

2 a light transmissive substrate having a first surface and an opposing second
3 surface, the first surface having a diffraction grating pattern or a holographic image
4 pattern; and

5 a color shifting multilayer optical film on the second surface of the substrate,
6 the optical film comprising:

7 an absorber layer on the second surface of the substrate;

8 a dielectric layer on the absorber layer; and

9 a reflector layer on the dielectric layer;

10 wherein the optical film coating provides an observable color shift as the
11 angle of incident light or viewing angle changes.

12
13 10. The security article of claim 9, wherein the absorber layer comprises a
14 material selected from the group consisting of chromium, nickel, palladium, titanium,
15 vanadium, cobalt, iron, tungsten, molybdenum, niobium, ferric oxide, carbon, and
16 combinations or alloys thereof.

17
18 11. The security article of claim 9, wherein the absorber layer has a physical
19 thickness of about 30 Å to about 150 Å.

20
21 12. The security article of claim 9, wherein the dielectric layer has an index of
22 refraction of about 1.65 or less.

1 13. The security article of claim 12, wherein the dielectric layer comprises a
2 material selected from the group consisting of silicon dioxide, aluminum oxide, magnesium
3 fluoride, aluminum fluoride, cerium fluoride, lanthanum fluoride, sodium aluminum
4 fluorides, neodymium fluoride, samarium fluoride, barium fluoride, calcium fluoride, lithium
5 fluoride, and combinations thereof.

6
7 14. The security article of claim 9, wherein the dielectric layer is composed of an
8 organic material.

9
10 15. The security article of claim 9, wherein the dielectric layer comprises a
11 material selected from the group consisting of acrylates, perfluoroalkenes,
12 polytetrafluoroethylene, fluorinated ethylene propylene, and combinations thereof.

13
14 16. The security article of claim 9, wherein the dielectric layer has an index of
15 refraction of greater than about 1.65.

16
17 17. The security article of claim 16, wherein the dielectric layer comprises a
18 material selected from the group consisting of zinc sulfide, zinc oxide, zirconium oxide,
19 titanium dioxide, carbon, indium oxide, indium-tin-oxide, tantalum pentoxide, ceric oxide,
20 yttrium oxide, europium oxide, iron oxides, hafnium nitride, hafnium carbide, hafnium
21 oxide, lanthanum oxide, magnesium oxide, neodymium oxide, praseodymium oxide,
22 samarium oxide, antimony trioxide, silicon carbide, silicon nitride, silicon monoxide,
23 selenium trioxide, tin oxide, tungsten trioxide, and combinations thereof.

1 18. The security article of claim 9, wherein the dielectric layer has an optical
2 thickness in a range from about 2 QWOT at a design wavelength of about 400 nm to about
3 9 QWOT at a design wavelength of about 700 nm.

4
5 19. The security article of claim 9, wherein the reflector layer comprises a
6 material selected from the group consisting of aluminum, silver, copper, gold, platinum,
7 palladium, nickel, cobalt, tin, niobium, chromium, and combinations or alloys thereof.

8
9 20. The security article of claim 9, wherein the reflector layer is composed of a
10 magnetic material.

11
12 21. The security article of claim 20, wherein the magnetic material comprises a
13 cobalt-nickel alloy.

14
15 22. The security article of claim 9, wherein the reflector layer has a physical
16 thickness of about 300 Å to about 1000 Å.

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23. A security article comprising:

a light transmissive substrate having a first surface and an opposing second surface, the first surface having a diffraction grating pattern or a holographic image pattern; and

a color shifting optical coating on the second surface of the substrate, the optical coating including a polymeric medium and a plurality of color shifting multilayer optical interference flakes dispersed in the polymeric medium, each of the interference flakes comprising at least an absorber layer and a dielectric layer;

wherein the optical coating provides an observable color shift as the angle of incident light or viewing angle changes.

24. The security article of claim 23, wherein each of the flakes has a dimension on any surface thereof ranging from about 2 to about 200 microns.

25. The security article of claim 23, wherein each of the flakes further comprises a reflector layer.

1 26. A security article comprising:

2 a light transmissive substrate having a first surface and an opposing second
3 surface, the first surface having a diffraction grating pattern or a holographic image
4 pattern; and

5 a color shifting pigment dispersed within the substrate and comprising a
6 plurality of multilayer optical interference flakes, each of the interference flakes
7 comprising at least an absorber layer and a dielectric layer, the pigment providing an
8 observable color shift as the angle of incident light or viewing angle changes.

9
10 27. The security article of claim 26, wherein each of the flakes has a dimension
11 on any surface thereof ranging from about 2 to about 200 microns.

12
13 28. The security article of claim 26, wherein each of the flakes further comprises
14 a reflector layer.

1 29. A method of forming a security article, comprising the steps of:
2 providing a light transmissive substrate having a first surface and an opposing
3 second surface, the first surface having an optical interference pattern; and
4 forming a color shifting optical coating on the second surface of the substrate,
5 the optical coating providing an observable color shift as the angle of incident light
6 or viewing angle changes.

7
8 30. The method of claim 29, wherein the substrate is composed of a plastic
9 material.

10
11 31. The method of claim 30, wherein the plastic material is selected from the
12 group consisting of polyethylene terephthalate, polycarbonate, polyvinyl chloride,
13 polyacrylates, polyacrylonitrile, polystyrene, polypropylene, polynaphthalene terephthalate,
14 and mixtures or copolymers thereof.

15
16 32. The method of claim 29, wherein the optical interference pattern is formed
17 by embossing a diffraction grating pattern or a holographic image pattern on the first surface
18 of the substrate.

19
20 33. The method of claim 29, wherein the color shifting optical coating is formed
21 by depositing an absorber layer on the second surface of the substrate, and depositing a
22 dielectric layer on the absorber layer.

23
24 34. The method of claim 33, further comprising the step of depositing a reflector
25 layer on the dielectric layer.
26

1 35. The method of claim 34, wherein the absorber layer, the dielectric layer, and
2 the reflector layer are each deposited by physical vapor deposition.

3
4 36. The method of claim 29, wherein the color shifting optical coating is formed
5 by applying a color shifting ink comprising a plurality of multilayer optical interference
6 flakes dispersed in a polymeric medium to the second surface of the substrate.

7
8 37. The method of claim 29, wherein the color shifting optical coating is formed
9 on the second surface of the substrate by coextruding a color shifting material, comprising
10 a plurality of multilayer optical interference flakes dispersed in a polymeric medium, with
11 a material forming the substrate.

12
13 38. The method of claim 29, further comprising the step of forming a release layer
14 on the substrate.

15
16 39. The method of claim 38, further comprising the step of hot stamping the
17 security article to an object.

18
19 40. The method of claim 29, further comprising the step of attaching the security
20 article to an object.

21
22 41. The method of claim 40, wherein the object is selected from the group
23 consisting of security documents, monetary currency, credit cards, and merchandise
24 packaging.

1 42. A security article comprising:

2 a light transmissive substrate having a first surface and an opposing second
3 surface, the first surface having a diffraction grating pattern or a holographic image
4 pattern; and

5 a color shifting multilayer optical film on the first surface of the substrate, the
6 optical film comprising:

7 an absorber layer on the first surface of the substrate; and

8 a dielectric layer on the absorber layer;

9 wherein the optical film provides an observable color shift as the angle of
10 incident light or viewing angle changes

11
12 43. The security article of claim 42, wherein the substrate is composed of a plastic
13 material.

14
15 44. The security article of claim 42, wherein the optical film further comprises
16 a reflector layer on the dielectric layer.

17
18 45. The security article of claim 42, wherein the absorber layer comprises a
19 material selected from the group consisting of chromium, nickel, palladium, titanium,
20 vanadium, cobalt, iron, tungsten, molybdenum, niobium, ferric oxide, carbon, and
21 combinations or alloys thereof.

22
23 46. The security article of claim 42, wherein the wherein the dielectric layer
24 comprises a material selected from the group consisting of silicon dioxide, aluminum oxide,
25 magnesium fluoride, aluminum fluoride, cerium fluoride, lanthanum fluoride, sodium
26

1 aluminum fluorides, neodymium fluoride, samarium fluoride, barium fluoride, calcium
2 fluoride, lithium fluoride, and combinations thereof.

3
4 47. The security article of claim 42, wherein the dielectric layer is composed of
5 an organic material.

6
7 48. The security article of claim 42, wherein the dielectric layer comprises a
8 material selected from the group consisting of zinc sulfide, zinc oxide, zirconium oxide,
9 titanium dioxide, carbon, indium oxide, indium-tin-oxide, tantalum pentoxide, ceric oxide,
10 yttrium oxide, europium oxide, iron oxides, hafnium nitride, hafnium carbide, hafnium
11 oxide, lanthanum oxide, magnesium oxide, neodymium oxide, praseodymium oxide,
12 samarium oxide, antimony trioxide, silicon carbide, silicon nitride, silicon monoxide,
13 selenium trioxide, tin oxide, tungsten trioxide, and combinations thereof.

14
15 49. The security article of claim 44, wherein the reflector layer comprises a
16 material selected from the group consisting of aluminum, silver, copper, gold, platinum,
17 palladium, nickel, cobalt, tin, niobium, chromium, and combinations or alloys thereof.

18
19 50. The security article of claim 44, wherein the reflector layer is composed of
20 a magnetic material.

21
22 51. The security article of claim 42, further comprising a release layer on the
23 second surface of the substrate.

24
25 52. The security article of claim 42, further comprising an adhesive layer on the
26 optical film.

ABSTRACT OF THE INVENTION

A security article includes a light transmissive substrate having a first surface and an opposing second surface, with the first surface having an embossed region with an optical diffraction pattern or a holographic image pattern. A color shifting optical coating is formed on the substrate such as on the opposing second surface, with the optical coating providing an observable color shift as the angle of incident light or viewing angle changes. The security article can be used in a variety of applications and products to provide for enhanced security measures such as anticounterfeiting.

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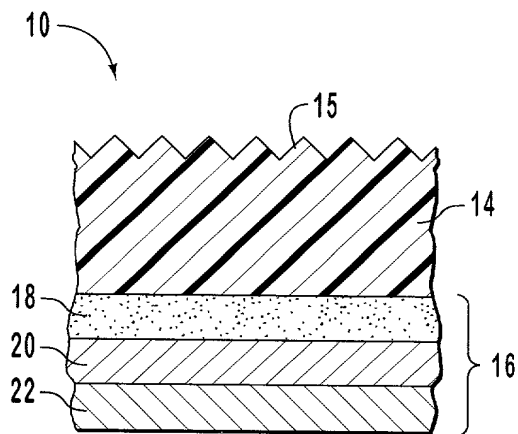


FIG. 1A

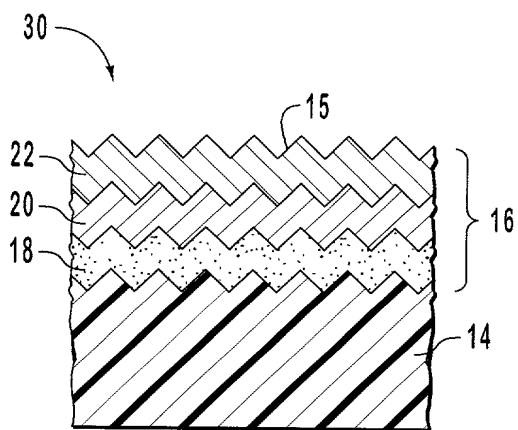


FIG. 1B

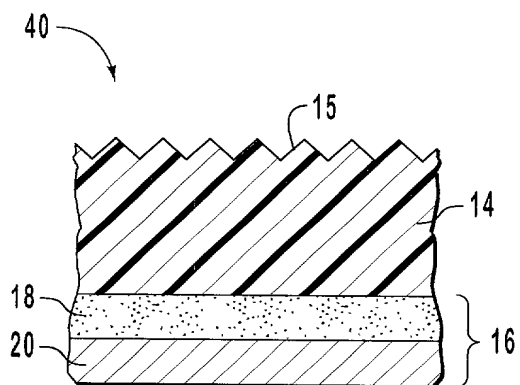


FIG. 2A

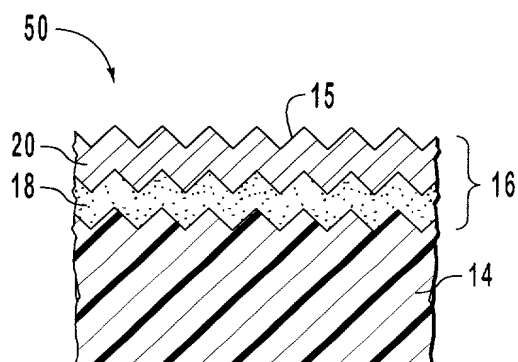


FIG. 2B

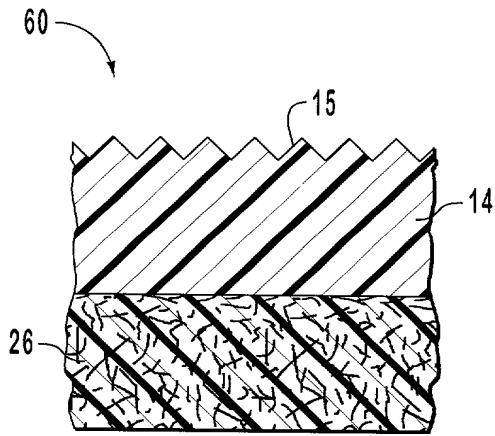


FIG. 3

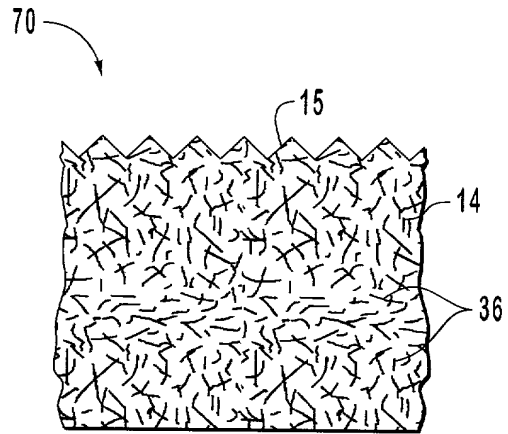


FIG. 4

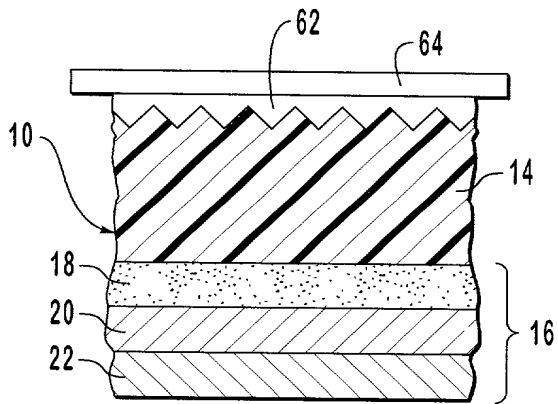


FIG. 5

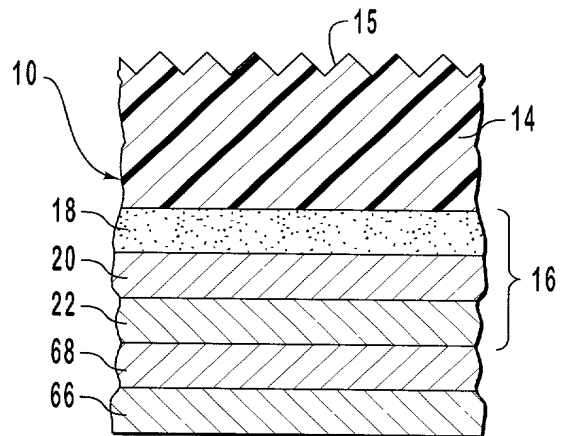


FIG. 6

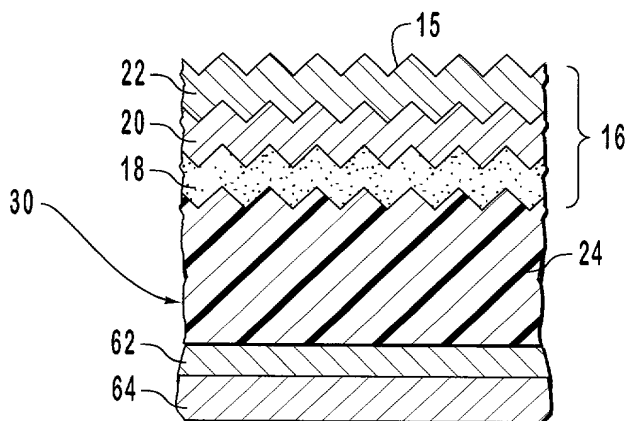


FIG. 7

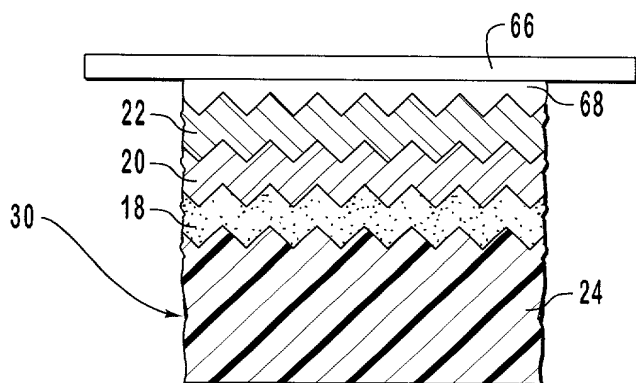


FIG. 8